



High-Fidelity Full System Simulations

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National Aeronautics and
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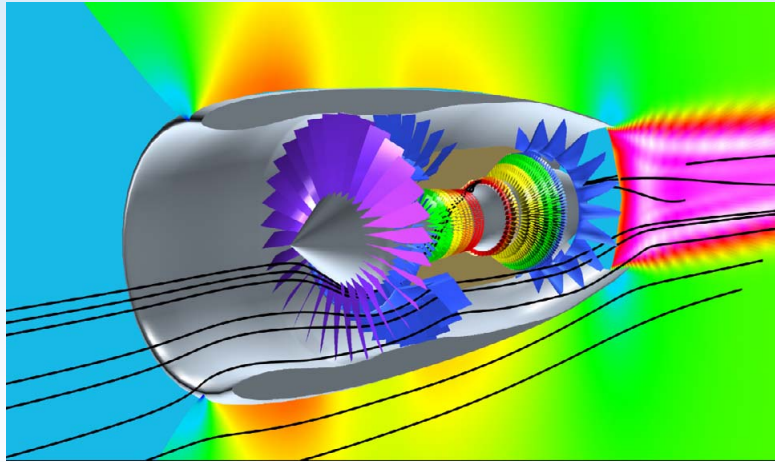
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High-Fidelity Full System Simulations

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Cleveland, Ohio 44135

High-fidelity full system simulations have the potential for revolutionizing the way complex systems, such as propulsion systems for aerospace vehicles, are designed, developed, manufactured, and operated. Significant time and cost savings will result from simulations that will resolve deleterious component interactions early in the design process. In addition, innovative new system configurations will result from the use of new tools that enable designers to challenge traditional rules and practices. The major challenges to developing and implementing high-fidelity systems simulations are in reducing the time and effort required to build, execute, and analyze data for the high complex simulations. In addition, large scale testing with unique instrumentation is required to validate the simulations. The solution to these problems reside in the application of advanced information technologies to assist the user to effectively manage, process, and synthesize the vast amount of data. The following presentation describes in more detail the benefits of high-fidelity full system simulations, the challenges to developing and implementing large scale simulations, and one approach that is being followed by the NASA Glenn Research Center to overcome these challenges. In addition, topics for discussion by the panel and audience are suggested.

High-fidelity Full System Simulation The Virtual Engine Test Cell



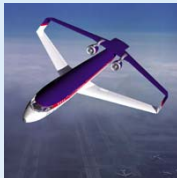
Dr. John K. Lytle
40th Joint Propulsion Conference
July 13, 2004

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Major Issue in Meeting the National Needs



- **The nation's ability to develop advanced propulsion systems for aviation and space exploration is at high risk due to increasing complexity and cost.**
 - The complexity of modern and future aerospace systems is pushing the limits of our engineering abilities. Across the DoD, FAA, NASA and industry there is a disturbing rate of cost overruns, schedule slips and aerospace systems that don't achieve planned capability"NASA Associate Administrator, Tech Day on the Hill, 2001
 - "...Without significant reductions in cost, the nation cannot afford a new military aircraft engine..." DDRE, IHPTET Steering Committee Meeting, 1996
- **New and innovative technologies are needed that enable**
 - **High-Confidence**
 - Performance
 - Operability
 - Life
 - **Rapid and Cost-Effective System Design and Development**

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Virtual Testing Projected to Save \$100s M in Development Costs!!

- A NASA/Industry Team Estimates a 30% to 40% Reduction in Commercial Engine Development Time and Cost using Virtual Testing.
- DOD Study* of Military Engine Development Estimates a 50% Reduction in Development Time and Cost with Design through Virtual Testing.
 - *“THE SUCCESSFUL DEVELOPMENT OF THIS DESIGN SYSTEM REQUIRES THE ESTABLISHMENT OF A FORMAL RELATIONSHIP AMONG NASA’S NPSS PROGRAM AND DOD’S IHPTET PROGRAM & HCF INITIATIVE, AND THE SUPPORT OF INDUSTRY”*
 - TIMETABLE: 2003 - DESIGN SYSTEM DEVELOPED & IN PLACE
2003-2009 - DESIGN SYSTEM VALIDATION
2009 - FULLY QUALIFIED SYSTEM, READY FOR USE

*Integrated High Performance Turbine Engine Technology (IHPTET) Program, 1998

HCF – High Cycle Fatigue

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Summary of IHPTET Cost Reduction Panel Study

IHPTET Study of Military Engine Development Estimates a 50% Reduction in Development Cost with Design through Virtual Engine Testing*

- ..the predictive accuracy of advanced simulation and design tools will have to improve significantly...
- ...future automated design software should focus on the development of highly accurate, three dimensional, multi-disciplinary (aerodynamic, thermodynamic, structural, and secondary flow) engine design systems....a virtual engine test cell
- Projected benefits of a virtual engine test cell to a notional development program (F100, F404, F414, F119) of ten years, \$1.5B effort, 14 test engines, 9 flight test engines and over 11,000 hours of engine tests.
 - 50% reduction in tooling cost
 - 33% reduction in the average development engine cost
 - 30% reduction in the cost of fabricating, assembling and testing rig hardware
 - 36% reduction in the number of development engines
 - 60% reduction in total hardware cost

*Skira, Charles, A., "Will There Ever Be a Another New Military Aircraft Engine Development Program?", AIAA 99-2660

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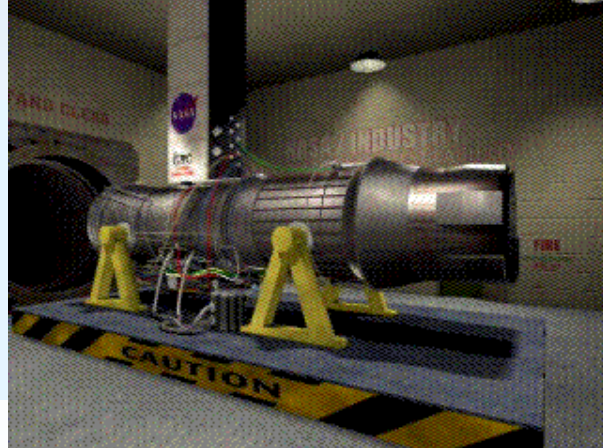
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The Vision

An advanced engineering analysis environment that enables high-fidelity, multi-disciplinary, full propulsion system simulations to be performed early in the design process....

...a virtual test cell that augments physical testing through the integration of physics-based modeling and information technologies...

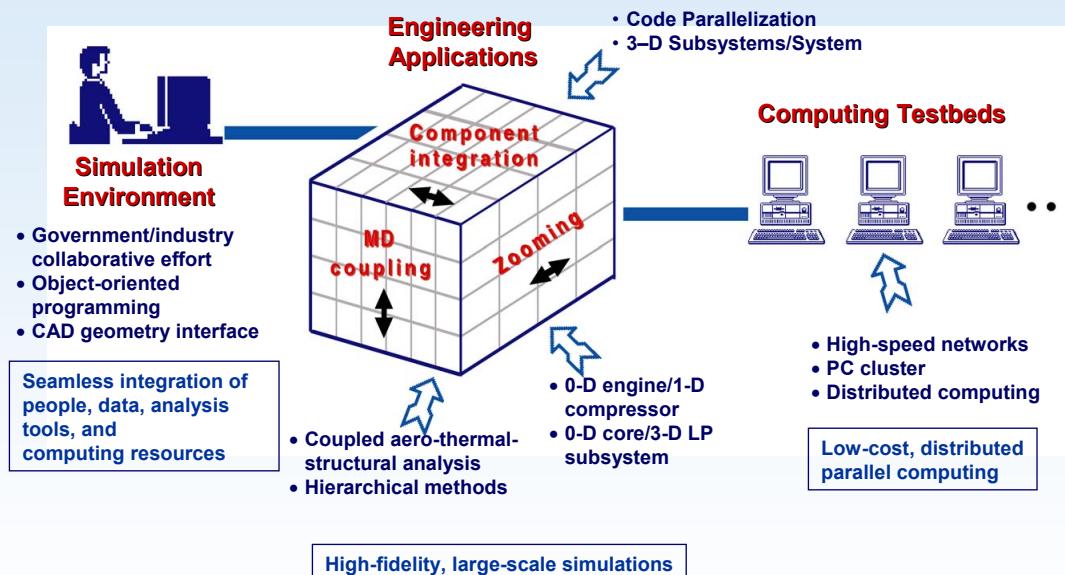


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Major Elements



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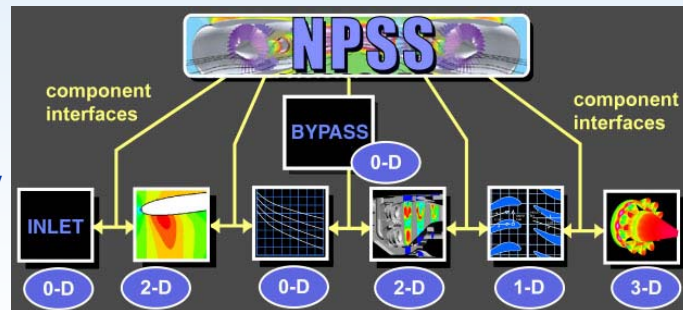
The Numerical Propulsion System Simulation

One Approach to High-fidelity Simulation

The Simulation Environment

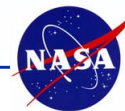
A modern modular, extensible software architecture

- Object-oriented
- Multi-fidelity
- Multi-disciplinary
- Distributed



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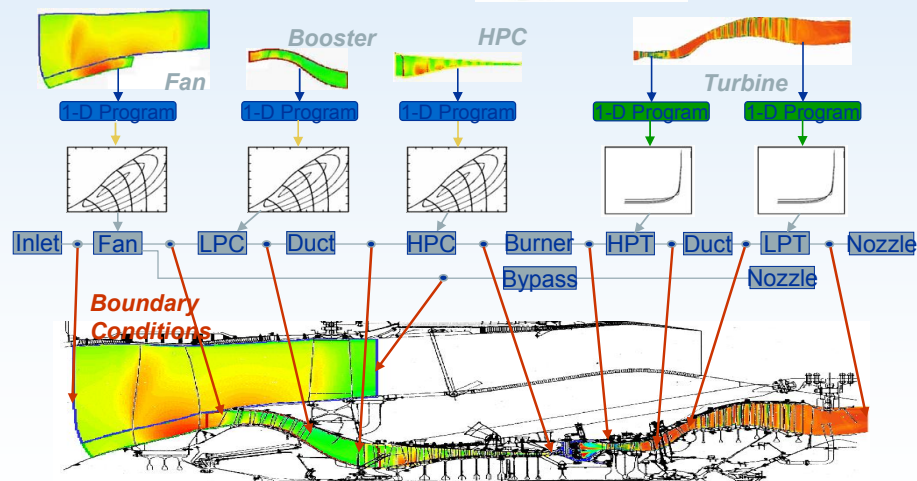
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The Numerical Propulsion System Simulation

One Approach to High-fidelity Simulation

Engineering Applications



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The Numerical Propulsion System Simulation

One Approach to High-fidelity Simulation

Low-cost, High-performance Computing



AEROSHARK Cluster 128 Processors

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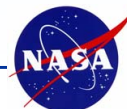


Topic for Discussion

- Do high-fidelity integrated, full system simulations have the potential to revolutionize propulsion system design and development?
- What are the major challenges in developing and implementing Virtual Engine Testing?
- Are technologies available today to begin the implementation?
- What technologies are needed to fully develop the capability?

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